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Measuring the “Will to Fight” in Simulation

A limited excursion into JWARS “Soft Factors”
with an emphasis on Morale and Cohesion

By

Paul J. Bross

Lockheed Martin Corporation

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Crisis

POL-MIL Plan

- Developed by NSC-PCC
- Frames crisis response and identifies end-state
- Guidance to relevant elements of national power (DIME) to achieve strategic objectives
- Provides: **Strategic Objectives & Policy Aims**

[CPG* simulates Coalition policy decisions]

Effects Based Plan (EBP)

- Developed by SJFHQ and RCC Staff with JIACG* as advisory element
- ONA links DIME Actions to relevant PMESII* Nodes to achieve desired Effects

Operational Net assessment (ONA)

- Developed by SJFHQ Includes:
 - 27 Desired Effects
 - Linked:
 - 52 potential DIME Actions
 - 1200 Nodes

•Assign

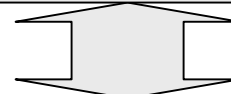
- **Execute Operations**
- **Conduct Effects Assessment**

DImE COA Analysis

SEAS

Agent-based DImE Campaign

- Models ONA Actions on PMESII Nodes
 - interactions, synergy, and muting
- Quantifies Impacts of DIE Actions



JWARS

Military Campaign

- Models Blue and Red combat
- Quantifies Impacts of Mil Actions

*CPG: Coalition Planning Group

*JIACG: Joint Inter-Agency Coordination Group

*PMESII: political, military, economic, social, information, and infrastructure

Relationship Between Pol-Mil Plan, EBP/O, ONA & Simulation Tools



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Synthetic Environment for Analysis and Simulation (SEAS)

Input Screen
DIME Actions
Iran

suvvUI - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Reload Home Search Favorites Media Print Mail

Address K:\SUV_May_17\UI\suvvUI.html

simulex 1.0
SEAS Unified Vision

JIACG Player 3 Logout

Input Mode: **Timeline Mode**

Input for time: 3

Action	Value	Category	Priority
Direct diplomatic engagement	1	AID	D
Form coalition	2	DOC	D
Seek UNSC resolution	2	DOD	D
Media campaign in country of interest	1	DOD	I
Computer Network Operations	3	AID	I
Electronic attack	0	AID	I
PSYOPS against country of interest	2	DOD	I
Take direct action against country of interest	3	DOD	M

Output for time: 2

Tactical-Will to fight	+30%
Operational-Will to fight	+23%
Strategic-Will to fight	+15%

System Status:
[09h:46m:49s] Output history retrieved successfully
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[09h:46m:49s] Output retrieved

Check Load Save Confirm

Information Provided
Iran
Will to Fight for prior
period

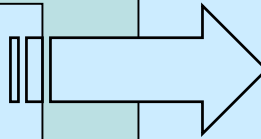
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Analytical Tasking

Will to Fight

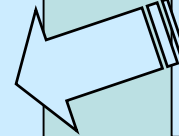
NGIC Factors

Ability to Assimilate
Air Defense
Battle Command
Combat Experience
Combat Service Support
Combined Arms Operations
Fire Support
Intelligence
Joint and Combined Operations
Leadership
Maneuver
Mobility and Survivability
Morale and Cohesion
Power Projection
Readiness
Training



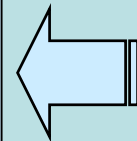
Behaviors

Breakpoints
Rate of Direct Fire
Speed of Maneuver
Suppression of Direct Fire
Suppression of Maneuver Speed
Comms Delay
Planning Delay
Time to Clear Obstacles



Unit Function

Combat
Combat Support
Combat Service

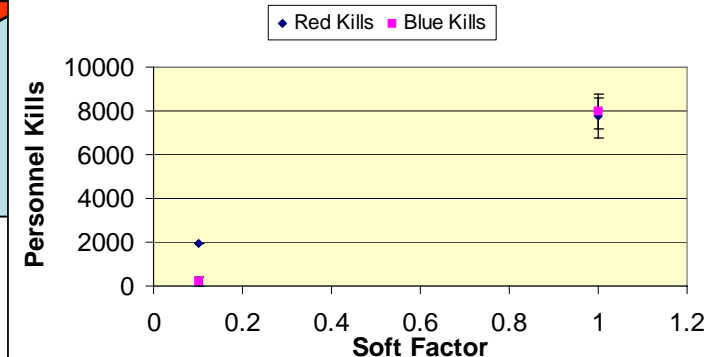


Ranking

Elite
Standard
Militia



Soft Factor Max Effects



- What is the impact of the “Will to Fight” on the combat outcomes?
- How sensitive is JWARS to the NGIC Morale and Cohesion Soft Factor?
- Determine if it will be worthwhile to pursue linkages between JWARS and SEAS to represent sociological effects on combat units and vice versa

Analytical Approach

- Step 1
 - Examine the foundation for the Soft Factors with emphasis on Morale and Cohesion
- Step 2
 - Determine if any elements could be addressed without simulation
- Step 3
 - Design and conduct appropriate simulation experiments

Soft Factor Fundamentals (1)

NGIC Factors

Ability to Assimilate
Air Defense
Battle Command
Combat Experience
Combat Service Support
Combined Arms Operations
Fire Support
Intelligence
Joint and Combined Operations
Leadership
Maneuver
Mobility and Survivability
Morale and Cohesion
Power Projection
Readiness
Training

- **National Ground Intelligence Center (NGIC) rates foreign countries on 16 factors**
- **NGIC does not rate US forces**
- **Methodology is Unclassified but Results are Classified**
- **NGIC rates for current, near future, far future time frames**
- **Each factor comprised of sub-components for scoring**

Soft Factor Fundamentals (2)

Unit Function

Combat
Combat Support
Combat Service

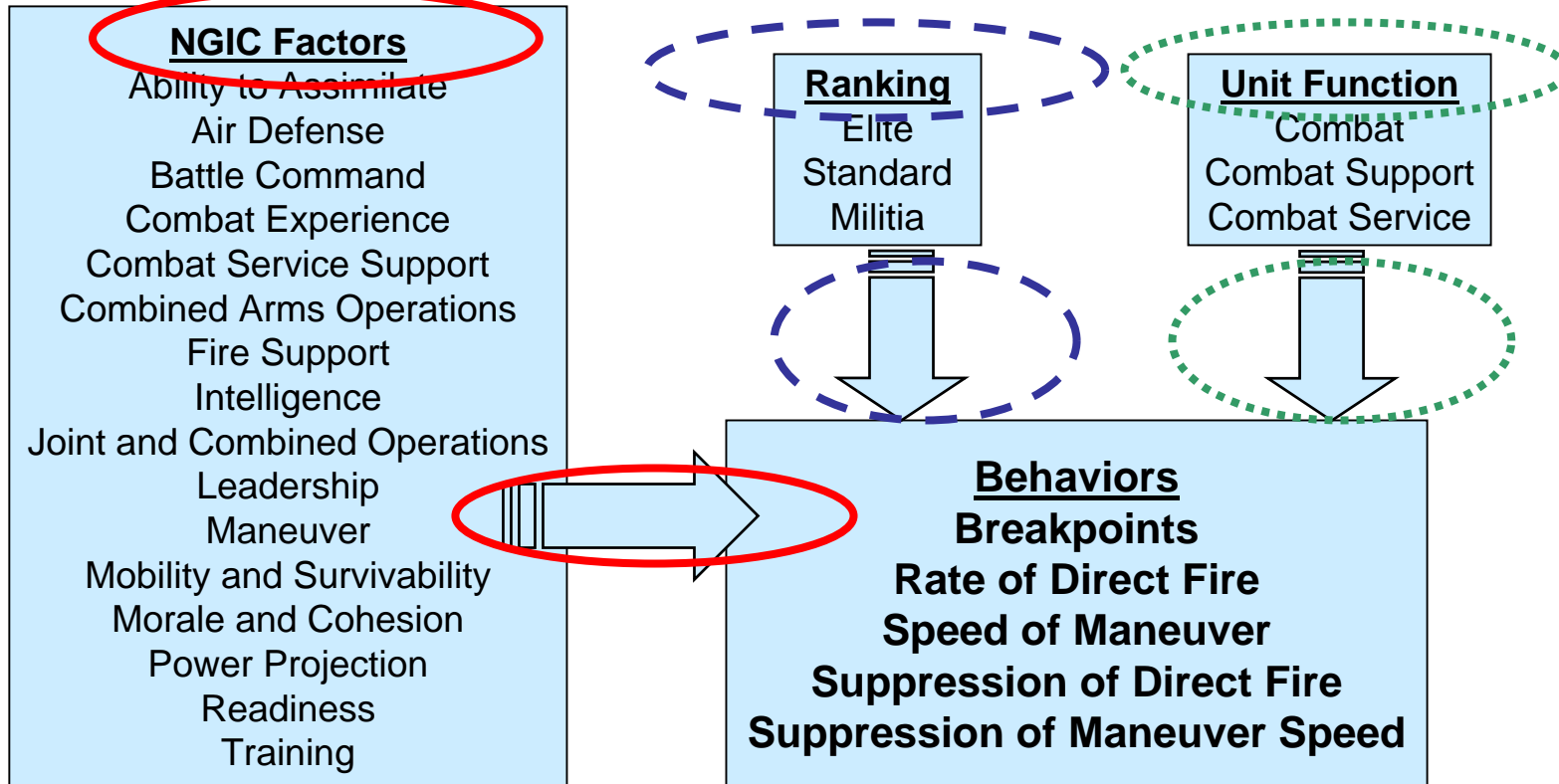
**No difference for
RED and BLUE**

Ranking

Elite
Standard
Militia

- Unit Function based on role in combat
 - Combat units rated at 1.0
 - All other units rated below 1.0
 - In general: $CBT = 1.0 > CS > CSS$
 - No data source other than the analyst
-
- Unit Ranking based on expertise
 - Elite units ranked at 1.0
 - All other units rated below 1.0
 - In general: $E = 1.0 > S > M$
 - No data source other than the analyst

Soft Factor Fundamentals (3)



$$SF_{Behavior} = (1 - (N_{\%} * (1 - N))) * (1 - (R_{\%} * (1 - R))) * (1 - (F_{\%} * (1 - F)))$$

Soft Factor Equation

$$SF_{Behavior} = (1 - (N_{\%} * (1 - N))) * (1 - (R_{\%} * (1 - R))) * (1 - (F_{\%} * (1 - F)))$$

SF = Soft Factor Value, $0 \leq SF \leq 1$

where 0 = Totally Ineffective and 1 = Totally Effective

$N_{\%}$ = amount of composite NGIC score applied, $0 \leq N_{\%} \leq 1$

N = normalized composite NGIC score, $0 \leq N \leq 1$

$R_{\%}$ = amount of Ranking Factor applied, $0 \leq R_{\%} \leq 1$

R = Ranking Factor, $0 \leq R \leq 1$

$F_{\%}$ = amount of Combat Function score applied, $0 \leq F_{\%} \leq 1$

F = normalized Combat Function score, $0 \leq F \leq 1$

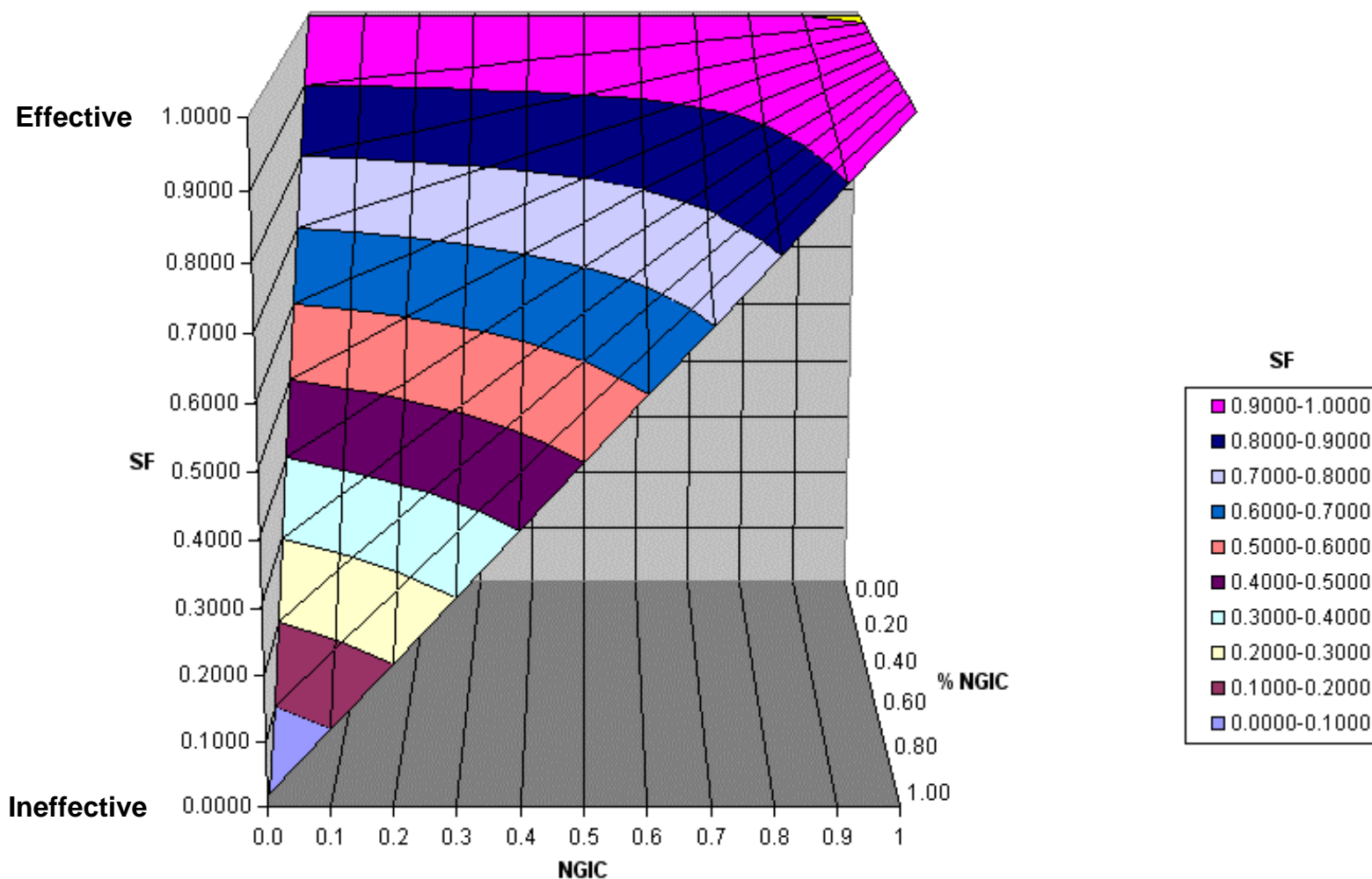
Soft Factor for Elite Combat Units

$$SF_{Behavior} = (1 - (N_{\%} * (1 - N))) * (1 - (R_{\%} * (1 - R))) * (1 - (F_{\%} * (1 - F)))$$

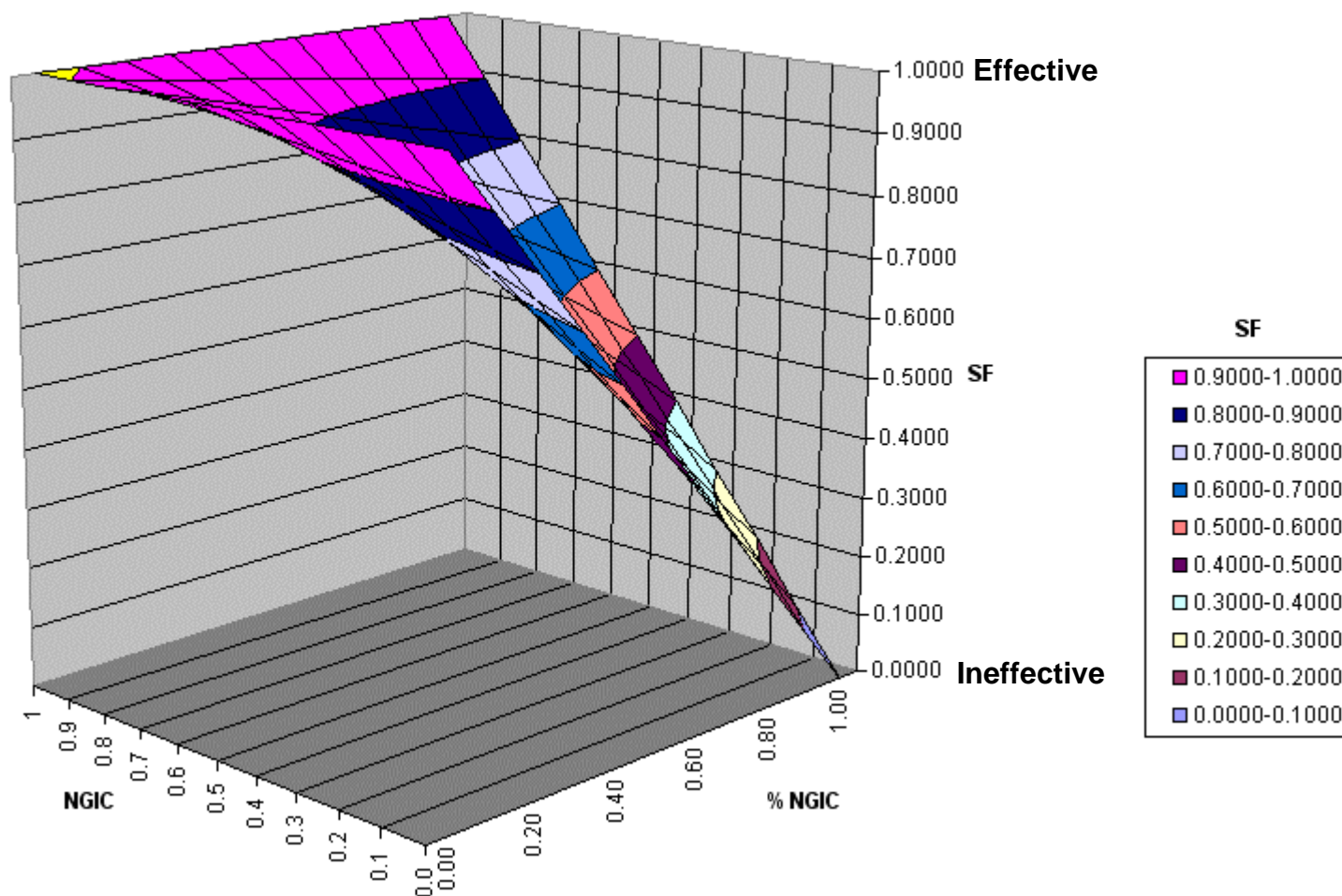
$N_{\%}$

N	0.0000	0.1000	0.2000	0.3000	0.4000	0.5000	0.6000	0.7000	0.8000	0.9000	1.0000
0.0000	1.0000	0.9000	0.8000	0.7000	0.6000	0.5000	0.4000	0.3000	0.2000	0.1000	0.0000
0.1000	1.0000	0.9100	0.8200	0.7300	0.6400	0.5500	0.4600	0.3700	0.2800	0.1900	0.1000
0.2000	1.0000	0.9200	0.8400	0.7600	0.6800	0.6000	0.5200	0.4400	0.3600	0.2800	0.2000
0.3000	1.0000	0.9300	0.8600	0.7900	0.7200	0.6500	0.5800	0.5100	0.4400	0.3700	0.3000
0.4000	1.0000	0.9400	0.8800	0.8200	0.7600	0.7000	0.6400	0.5800	0.5200	0.4600	0.4000
0.5000	1.0000	0.9500	0.9000	0.8500	0.8000	0.7500	0.7000	0.6500	0.6000	0.5500	0.5000
0.6000	1.0000	0.9600	0.9200	0.8800	0.8400	0.8000	0.7600	0.7200	0.6800	0.6400	0.6000
0.7000	1.0000	0.9700	0.9400	0.9100	0.8800	0.8500	0.8200	0.7900	0.7600	0.7300	0.7000
0.8000	1.0000	0.9800	0.9600	0.9400	0.9200	0.9000	0.8800	0.8600	0.8400	0.8200	0.8000
0.9000	1.0000	0.9900	0.9800	0.9700	0.9600	0.9500	0.9400	0.9300	0.9200	0.9100	0.9000
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

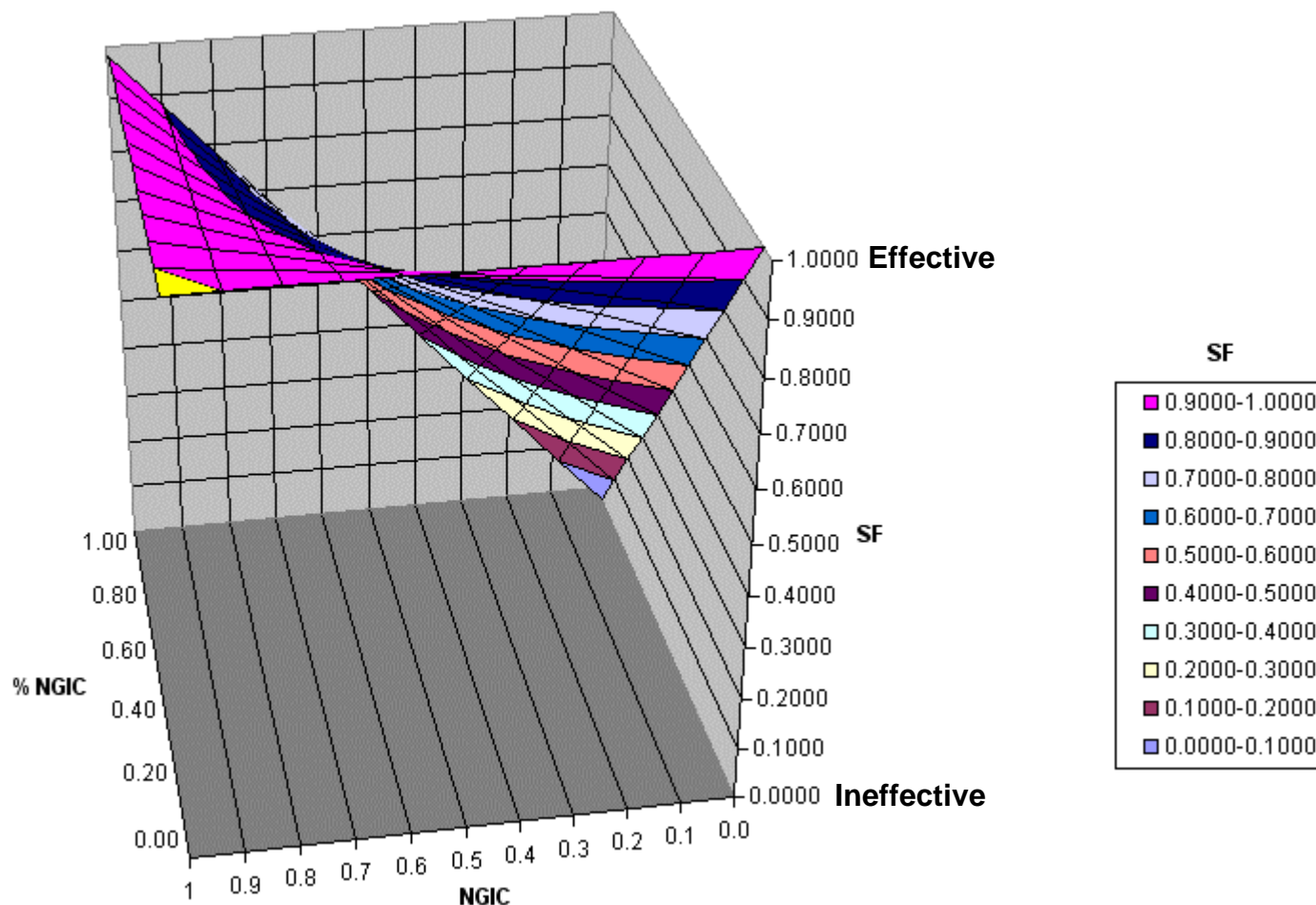
Soft Factor affected by NGIC and %NGIC Score



Soft Factor affected by NGIC and %NGIC Score



Soft Factor affected by NGIC and %NGIC Score





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Soft Factor Settings

Most Effective

	Combat	Combat Support	Combat Service Support
Elite	1.000	0.600	0.300
Standard	0.700	0.420	0.210
Militia	0.400	0.240	0.120

	Combat	Combat Support	Combat Service Support
Elite	0.900	0.540	0.270
Standard	0.630	0.378	0.189
Militia	0.360	0.216	0.108

	Combat	Combat Support	Combat Service Support
Elite	0.800	0.480	0.240
Standard	0.560	0.336	0.168
Militia	0.320	0.192	0.096

	Combat	Combat Support	Combat Service Support
Elite	0.700	0.420	0.210
Standard	0.490	0.294	0.147
Militia	0.280	0.168	0.084

	Combat	Combat Support	Combat Service Support
Elite	0.600	0.360	0.180
Standard	0.420	0.252	0.126
Militia	0.240	0.144	0.072

	Combat	Combat Support	Combat Service Support
Elite	0.500	0.300	0.150
Standard	0.350	0.210	0.105
Militia	0.200	0.120	0.060

	Combat	Combat Support	Combat Service Support
Elite	0.400	0.240	0.120
Standard	0.280	0.168	0.084
Militia	0.160	0.096	0.048

	Combat	Combat Support	Combat Service Support
Elite	0.300	0.180	0.090
Standard	0.210	0.126	0.063
Militia	0.120	0.072	0.036

	Combat	Combat Support	Combat Service Support
Elite	0.200	0.120	0.060
Standard	0.140	0.084	0.042
Militia	0.080	0.048	0.024

	Combat	Combat Support	Combat Service Support
Elite	0.100	0.060	0.030
Standard	0.070	0.042	0.021
Militia	0.040	0.024	0.012

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Most Ineffective

S2

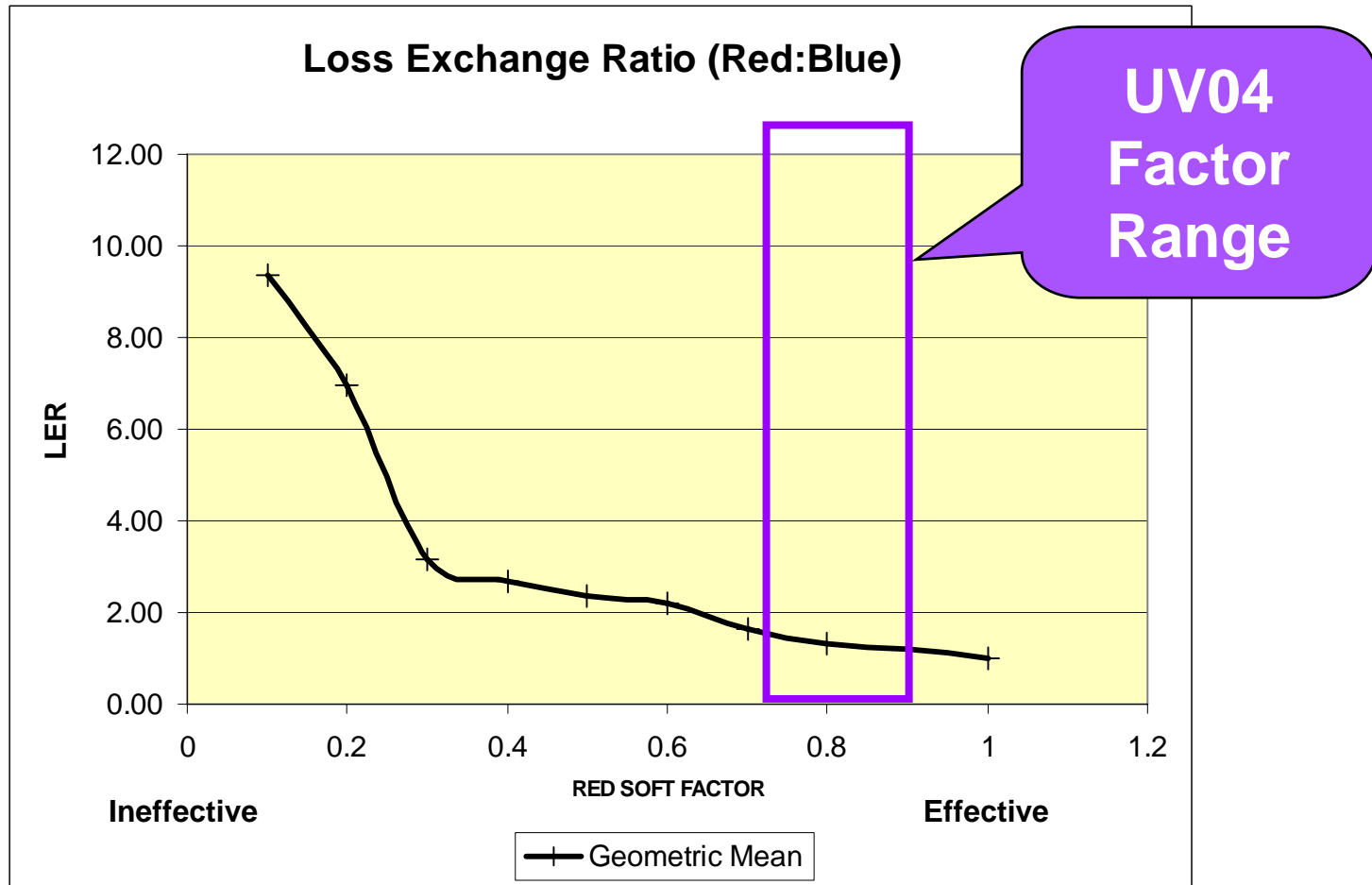
Simulation Experiments (a)

- Screen for Soft Factor Effects
 - Run opposite ends of spectrum (RED: SF = 0.1, SF = 1.0)
 - If first pairing shows major difference, complete the Soft Factor response curve (SF = 0.2, 0.3 0.9)
- Use UV04 Baseline Four 8-23-04 Scenario
 - Final UV04 baseline
 - Focus on RED and BLUE Troop Losses
 - Run 5 replications for each SF setting (n = 5)
- Determine succeeding steps after analyzing results of screening

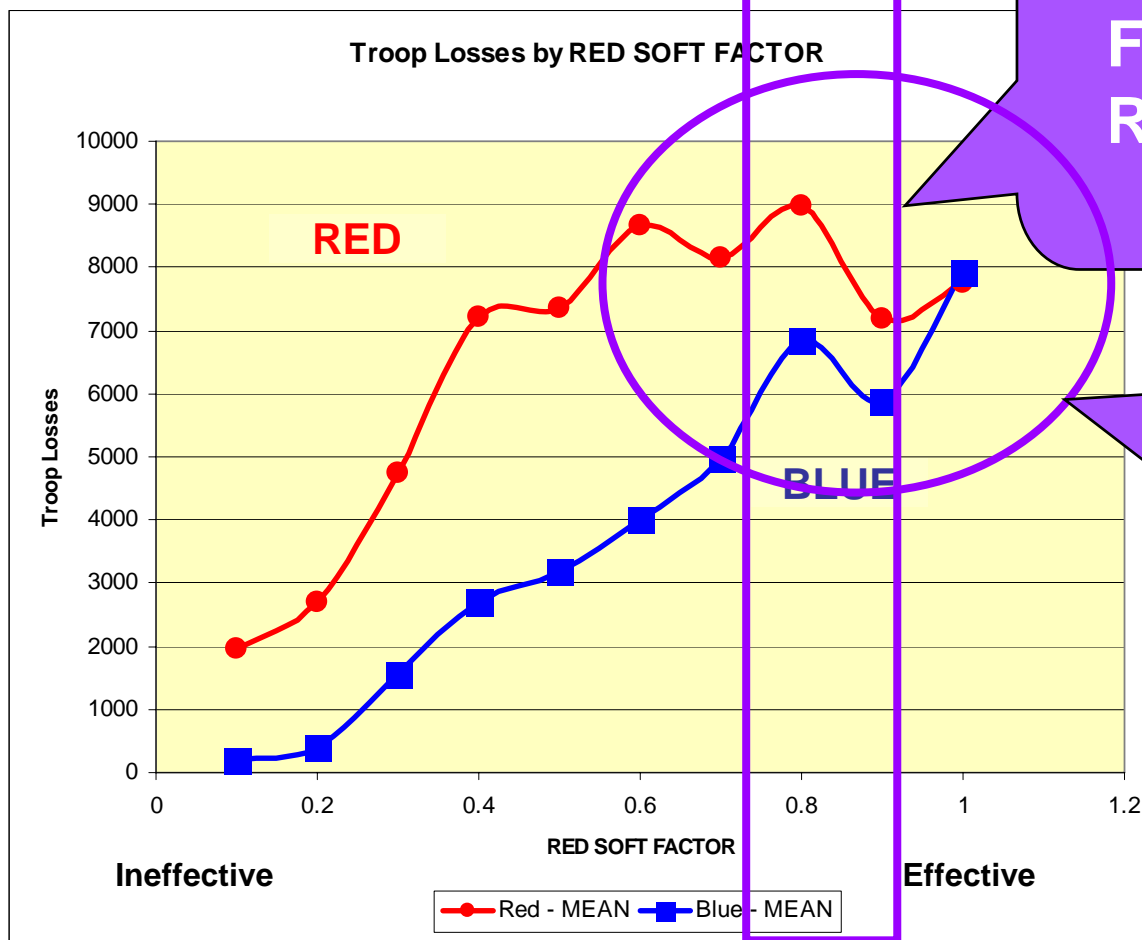
Loss Exchange Ratio

$$LER = \frac{Loss_{RED}}{Loss_{BLUE}}$$

- LER > 1 favors **BLUE**
- LER < 1 favors **RED**



Personnel Losses



UV04
Factor
Range

What is
happening
here?

Simulation Experiments (b)

- Investigate the “ripple” effect in the casualty measure as the Soft Factor varies at the upper end of the spectrum
 - Short screening experiment to determine if the five implemented behaviors are the cause
 - Breakpoints
 - Rate of Direct Fire
 - Suppression of Direct Fire
 - Maneuver Speed
 - Suppression of Maneuver Speed
 - Use a one-half replicate of a full factorial design = 16 reps
 - Identify primary behavior influence
 - Identify interaction effects (note: second- and third-order interactions are confounded in this design)
- Graduate to full factorial design (32 points) if time permits

Time
permitted!



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Design Matrix and Run Results

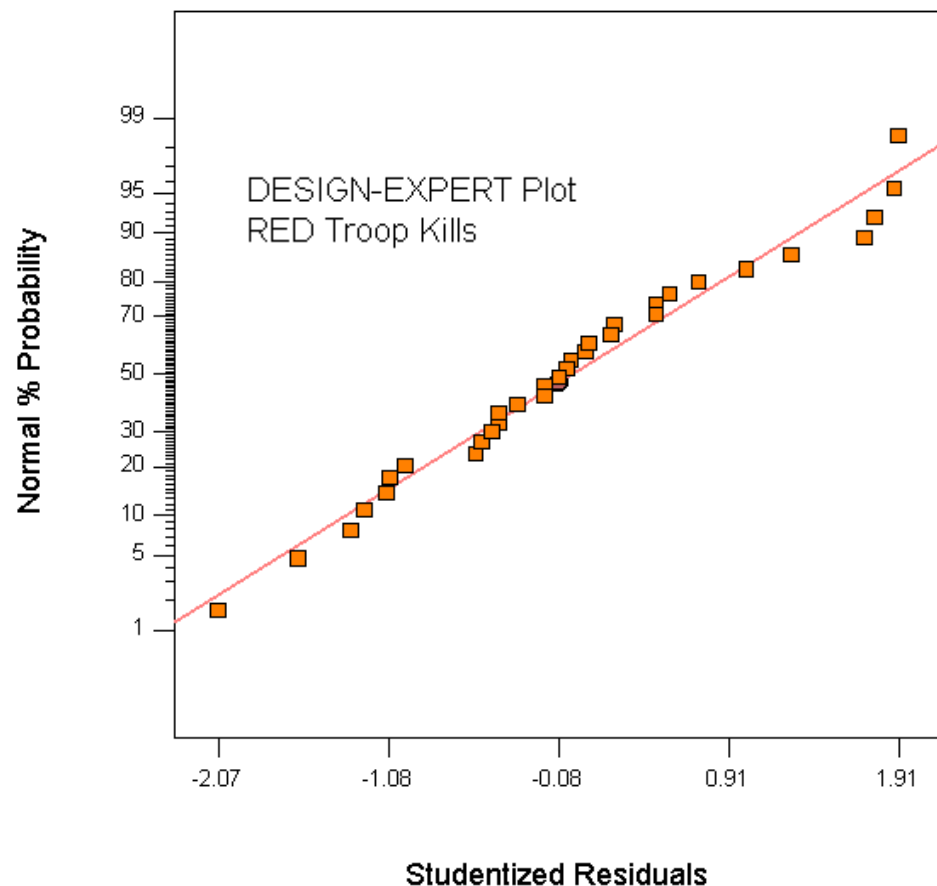
Behavior Design		Breakpoint	Rate-DF	Spd-Man	Sup-DF	Sup-ManSp	Troop	Kills
STD	RUN	A	B	C	D	E	RED	BLUE
8	1 Block 1	1	1	1	-1	-1	7515	6250
10	2 Block 1	1	-1	-1	1	1	10490	6203
5	3 Block 1	-1	-1	1	-1	-1	7316	5945
2	4 Block 1	1	-1	-1	-1	-1	10256	5788
7	5 Block 1	-1	1	1	-1	1	6135	5792
3	6 Block 1	-1	1	-1	-1	-1	8528	5715
1	7 Block 1	-1	-1	-1	-1	1	8763	5882
9	8 Block 1	-1	-1	-1	1	-1	8481	5609
13	9 Block 1	-1	-1	1	1	1	6439	4836
4	10 Block 1	1	1	-1	-1	1	10615	6078
11	11 Block 1	-1	1	-1	1	1	8736	6488
15	12 Block 1	-1	1	1	1	-1	7221	6483
14	13 Block 1	1	-1	1	1	-1	7501	6257
6	14 Block 1	1	-1	1	-1	1	8636	6203
12	15 Block 1	1	1	-1	1	-1	9732	6049
16	16 Block 1	1	1	1	1	1	8524	5789
21	17 Block 1	1	1	-1	1	1	10028	6115
20	18 Block 1	-1	-1	1	1	-1	7721	5781
31	19 Block 1	1	-1	-1	-1	1	10430	5795
30	20 Block 1	-1	1	-1	-1	1	8850	5786
17	21 Block 1	1	1	1	1	-1	7857	6537
32	22 Block 1	-1	-1	-1	-1	-1	8573	5510
24	23 Block 1	-1	-1	-1	1	1	8708	5751
19	24 Block 1	1	-1	1	1	1	8530	5184
18	25 Block 1	-1	1	1	1	1	6127	6133
28	26 Block 1	-1	-1	1	-1	1	5860	5959
29	27 Block 1	1	1	-1	-1	-1	9736	5206
27	28 Block 1	1	-1	1	-1	-1	8037	6836
25	29 Block 1	1	1	1	-1	1	8801	5673
26	30 Block 1	-1	1	1	-1	-1	7309	5812
23	31 Block 1	1	-1	-1	1	-1	9966	5127
22	32 Block 1	-1	1	-1	1	-1	8642	5853

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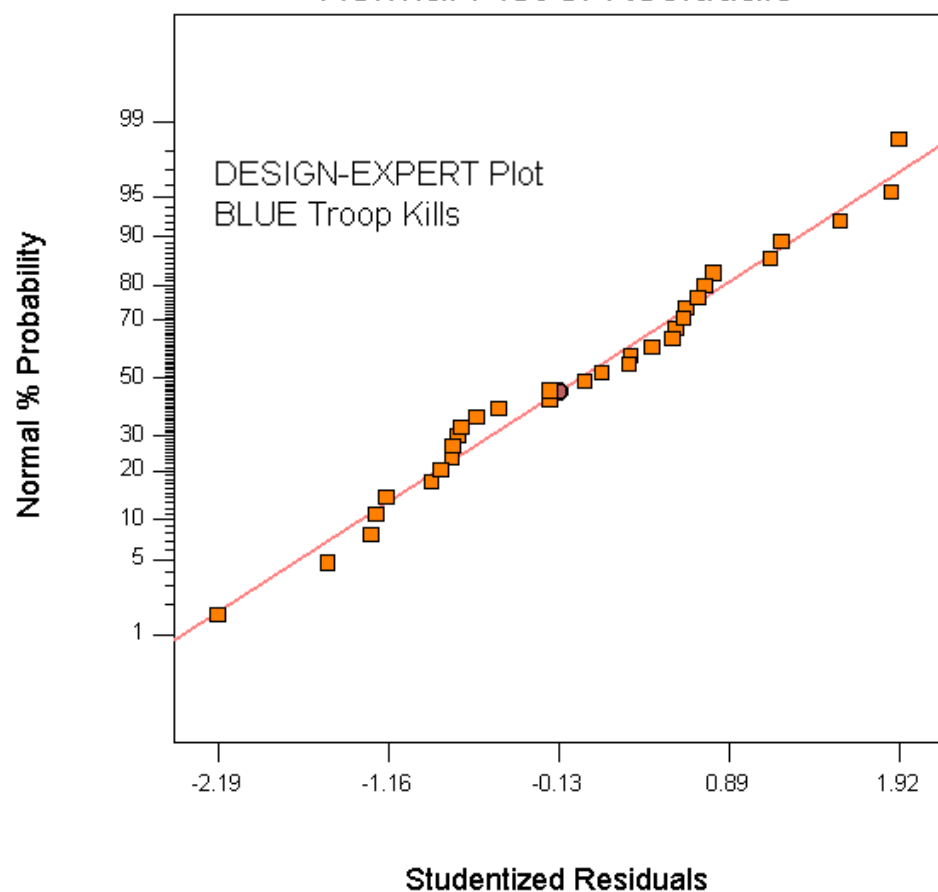
Normal Plot of Residuals

Normal Plot of Residuals



RED

Normal Plot of Residuals

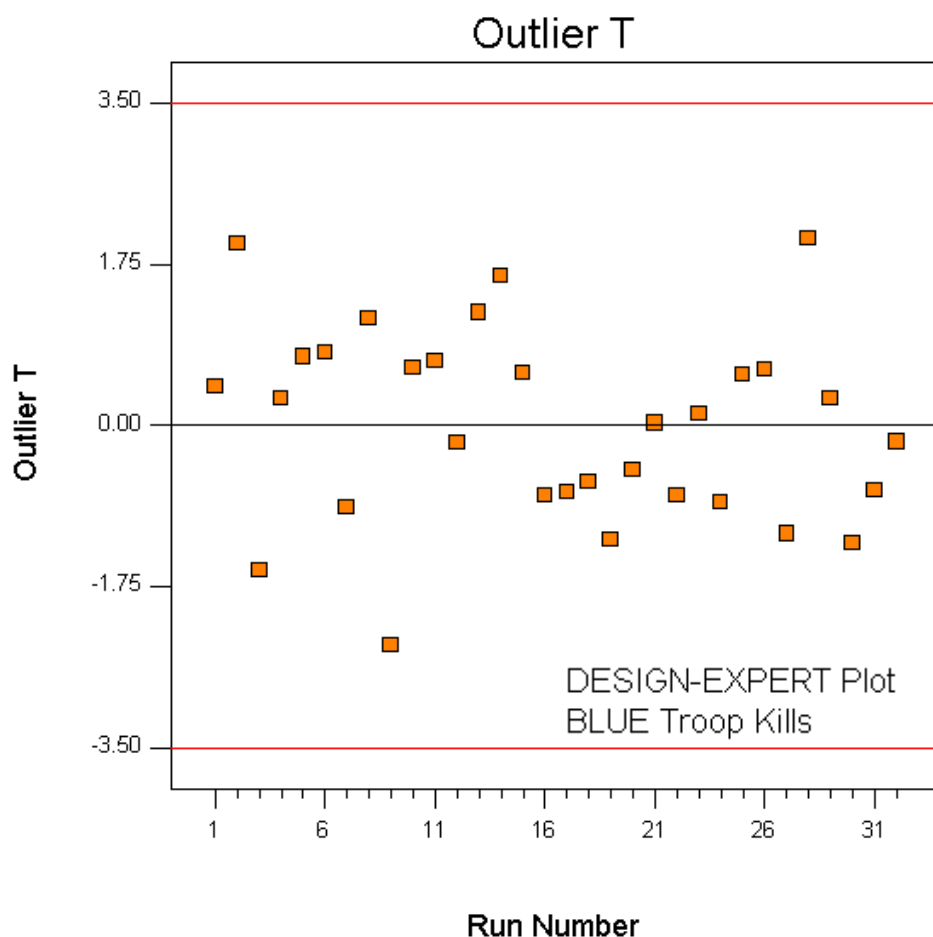


BLUE

Outlier T

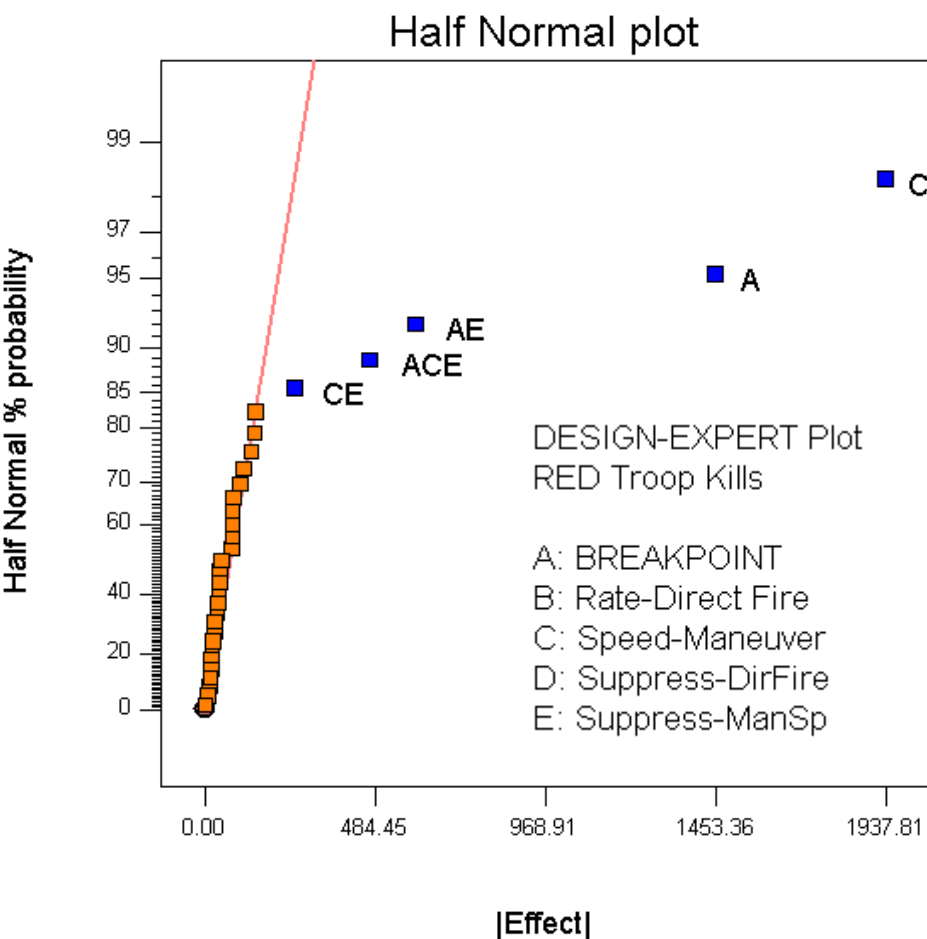


RED

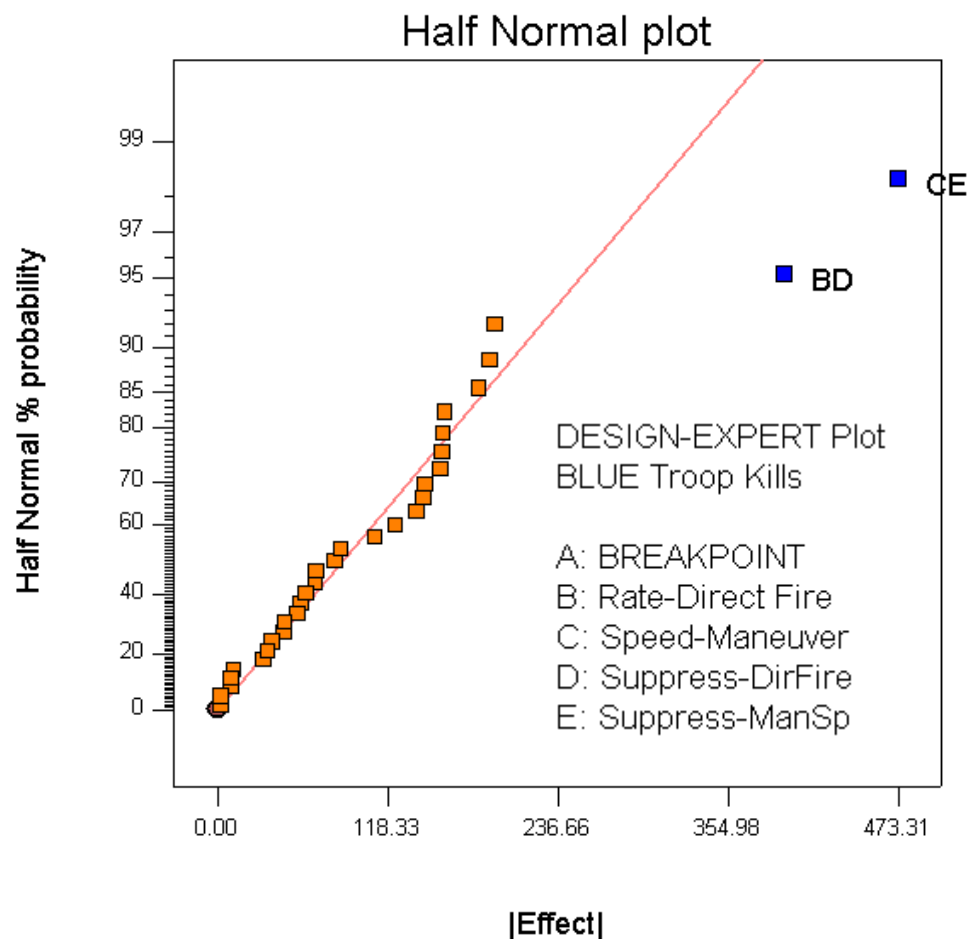


BLUE

Significant Effects



RED



BLUE



RED Soft Factor Response

ANOVA for Selected Factorial Model

Analysis of variance table [Partial sum of squares]

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Model	52202222.22	7	7457460.32	182.57	< 0.0001	significant
A	16885313.28	1	16885313.28	413.38	< 0.0001	
C	30040938.28	1	30040938.28	735.45	< 0.0001	
E	51280.03	1	51280.03	1.26	0.2736	
AC	15268.78	1	15268.78	0.37	0.5467	
AE	2896222.78	1	2896222.78	70.90	< 0.0001	
CE	533286.28	1	533286.28	13.06	0.0014	
ACE	1779912.78	1	1779912.78	43.58	< 0.0001	
Residual	980327.75	24	40846.99			
Cor Total	53182549.97	31				

DESIGN-EXPERT
RED Troop Kills

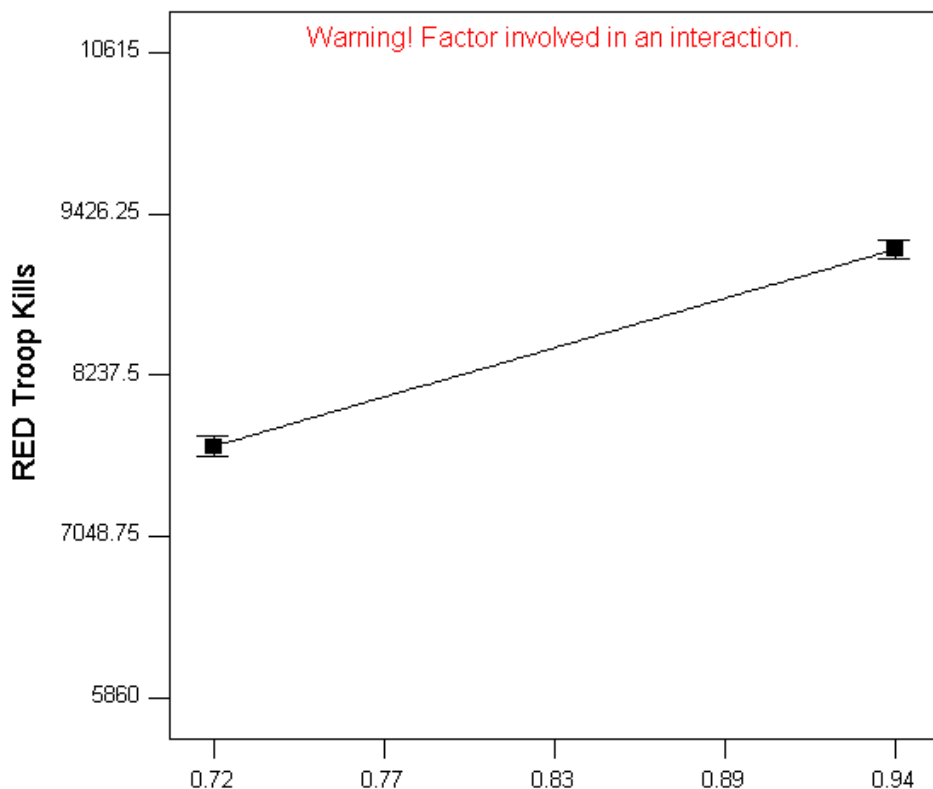
A: BREAKPOINT
B: Rate-Direct Fire
C: Speed-Maneuver
D: Suppress-DirFire
E: Suppress-ManSp

Preliminary Findings

- Some element of each behavior has significance but not the same for RED and BLUE
- Most behaviors are significant at the interaction level rather than the pure behavior level
- Next step – examine details

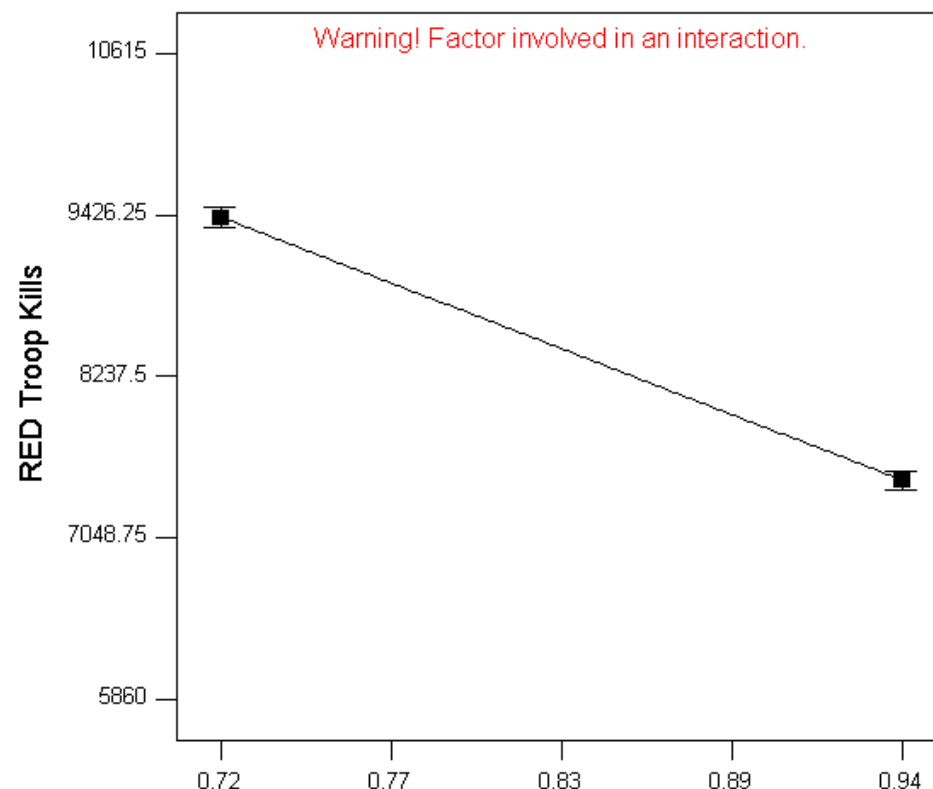
RED Single Factors

One Factor Plot



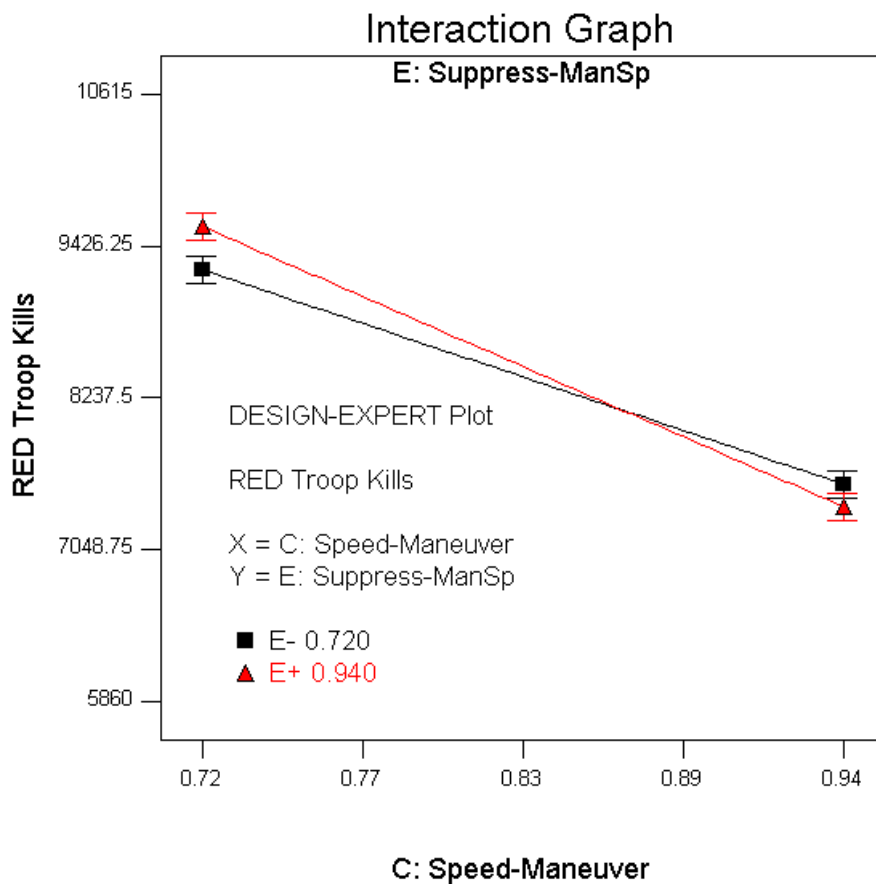
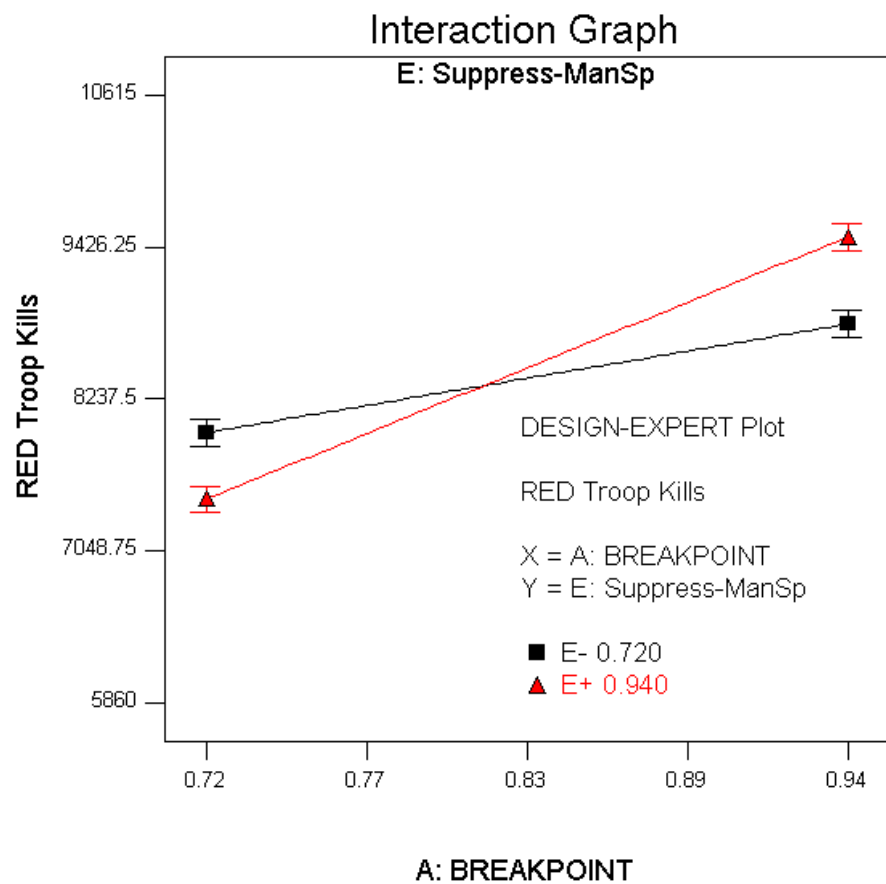
A: BREAKPOINT

One Factor Plot



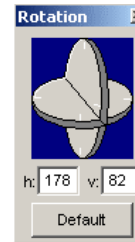
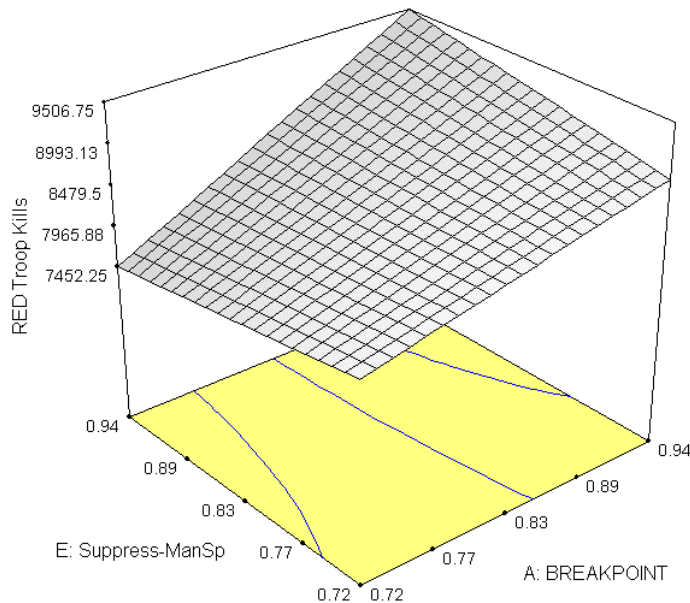
C: Speed-Maneuver

RED Interactions



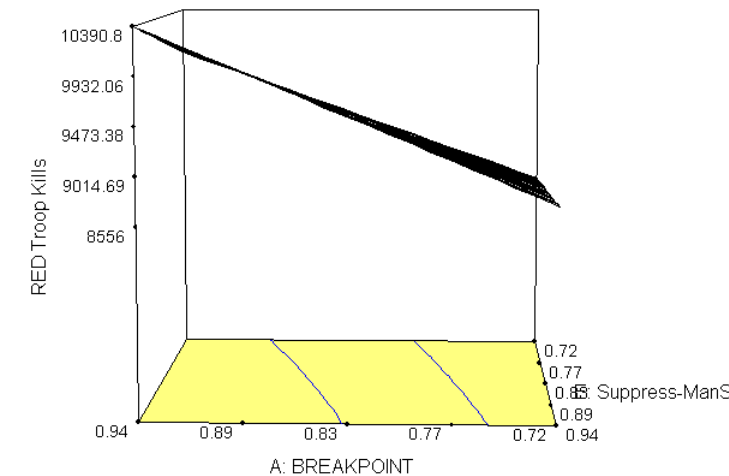
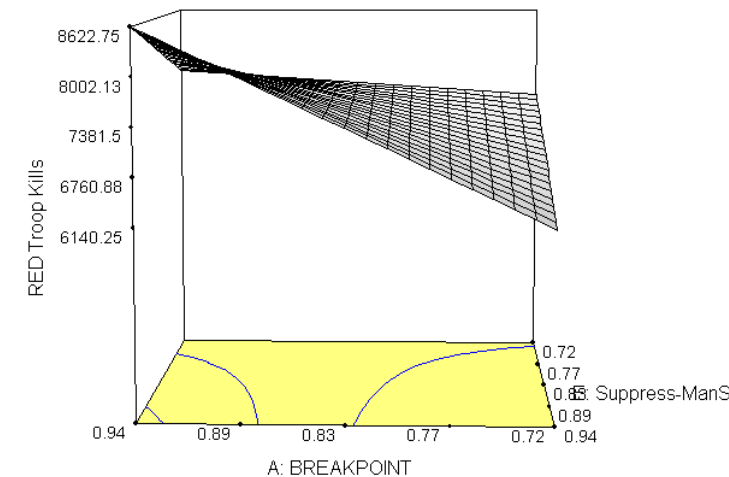
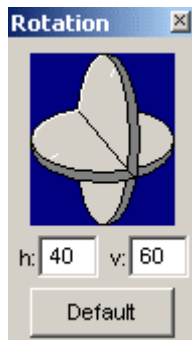
RED Breakpoint x Suppression of Maneuver Speed

Standard View



RED Troop Kills
X = A: BREAKPOINT
Y = E: Suppress-ManSp

Actual Factors
B: Rate-Direct Fire = 0.72
C: Speed-Maneuver = 0.72
D: Suppress-DirFire = 0.72





Analytical Tasking - Answers

- What is the impact of the “Will to Fight” on the combat outcomes?
 - Behavior effects are significant
 - Behavior effects are extremely non-linear
 - Behaviors reveal themselves mostly in interactions rather than in pure effects
- How sensitive is JWARS to the NGIC Morale and Cohesion (M&C) Soft Factor?
 - Experiment over the design space shows JWARS very sensitive to the M&C component
- Determine if it will be worthwhile to pursue linkages between JWARS and SEAS to represent sociological effects on combat units and vice versa
 - Based on NGIC criteria, it appears that a one-way JWARS-to-SEAS relationship may be appropriate



Recommendations

- Determine reasonable, defensible settings for:
 - Unit Ranking benchmarks (Elite, Standard, Militia)
 - Unit Function benchmarks (Combat, Combat Support, Combat Service Support)
 - Weights for each Behavior